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Land Use and Food Security in 2050: a Narrow Road

Agrimonde-Terra

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15. Regional Dimension of the Agrimonde-Terra Scenarios: The Example of sub-Saharan Africa

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Introduction

The Agrimonde-Terra team and Scenario Advisory Committee found it insightful to contextualize the five Agrimonde-Terra scenarios. Given the challenges in sub-Saharan Africa (SSA), it was decided to focus on this very large and diverse region. There are several 'Africas' even if there is a tendency to look at sub-Saharan Africa as one entity because of its limited role in the global economy (Hugon, 2016). Over past decades as in recent years, the growth momentum in sub-Saharan Africa has been very fragile. However, every year the gross domestic product (GDP) of several African countries grows by more than 7% while others record a very bad performance (IMF, 2017). Growth spells are frequent, both among resource-intensive and non-resource-intensive countries, but they tend to be shorter than in other regions of the world and to be characterized by large swings in growth which have a detrimental impact on investment and living conditions (IMF, 2017). The contribution of agriculture to GDP also varies highly among countries, from nearly 60% to less than 5% (IMF, 2016), but on average agriculture still occupies more than 58% of the economically active population (FAO, 2011a). Population growth has been very rapid between 1960 (221 million inhabitants) and 2015 (969 million inhabitants) (United Nations, World Population Prospects, 2017[65]), but there are vast differences in population numbers and densities between countries (Losch *et al.*, 2013). A number of countries contain large rural populations clustered in very small areas, while eight countries have low population densities over very large areas of arable land (Jayne *et al.*, 2014,

64. The authors thank Oluwabunmi Ajilore, Philippe Hugon and Véronique Lamblin for their comments.

65. https://esa.un.org/unpd/wpp/

p.1).[66] The prevalence of hunger in SSA has declined by –31% between 1990 and 2015, but one person in four is still undernourished and significant proportions of children are underweight, stunted or manifest various forms of undernutrition (FAO, 2015b). Western Africa has made significant progress towards the reduction of undernourished people, despite significant population growth and recurrent droughts in Sahel countries. Other sub-regions (especially Eastern and Central Africa with, respectively, 28% and 31% of the population suffering from food insecurity) experienced an increase in the absolute number of undernourished people, largely due to civil unrest, political instability, insufficient income and unfavourable climatic conditions (FAO, 2015b).

Past and on-going trends relative to the five dimensions of land use in SSA are presented in Chapter 5. In this chapter, we examine the trends in sub-Saharan Africa towards the different hypotheses for the future of external and direct drivers (Chapters 6 to 12), which have been used to build the five Agrimonde-Terra scenarios (Chapter 13). Then we look at the main on-going trends towards each scenario and we present how land use and food security would be in 2050 in SSA given the combination of assumptions. Sub-Saharan Africa is unique because on-going trends can be found towards all the scenarios identified by Agrimonde-Terra. In no other region of the world have the Agrimonde-Terra team and the Scenario Advisory Committee identified such a diversity of pathways. This diversity may represent an opportunity for the future of land use and food security in sub-Saharan Africa if local stakeholders and policymakers identify the trajectory(ies) that will lead to food security, especially local access to food (Bourgeois and Losch, 2017). They represent a threat, however, if no strategic choices are made as some pathways are contradictory. We conclude the chapter by suggesting some levers for action.

As a foresight process requires the participation of stakeholders with various competencies (Godet, 1994; Havas *et al.*, 2010; Bingley, 2016) but is costly in terms of time and money, this preliminary analysis can provide a basis for further discussions for the construction of land use and food security scenarios in sub-regions and countries of SSA, as has been done in Tunisia (de Lattre-Gasquet *et al.*, 2017a).

Trends in external drivers of change

We analyse here on-going trends and weak signals in SSA relative to the external drivers of change, *i.e.* the political, economic and social context, climate change and food diets, and use as a framework the hypotheses for the future presented in Chapters 6, 7 and 8. For ease of understanding, the names of these hypotheses are written in italics.

66. Democratic Republic of Congo, Angola, Congo, Zambia, Cameroon, Mozambique, Central African Republic and Gabon (source: Jayne *et al.*, 2014, table 1).

Trends relative to the political, economic and social context in SSA

In brief: there are concomitant on-going trends towards three hypotheses: '*Political and economic fragmentation*', '*Regionalization and energy transition*' and '*Conventional development led by market forces*', the latter two reinforcing fragmentation. Emerging trends are identified towards the hypotheses '*Non-state actors*' and '*Sustainable and cooperative world*', though the trends towards the latter assumption are weaker.

Population growth is a major marker of land use and food security at the SSA and household levels in 2050. Agrimonde-Terra has adopted the same demographic hypothesis for its five scenarios, based on UN World Population Prospects (2015 revision): from 2010 to 2050, population will increase by 192% in West Africa and by 155% in ECS Africa. By 2050, SSA's population is expected to reach almost 2.2 billion people (compared to 969 million in 2015), representing 23% of the global population (UN Population Prospects, 2015 revision). Youth aged 15 to 24 will account for 30% of the world's youth. The SSA youth will be both a great opportunity and a challenge for land use. On the one hand, the inactive population (youths under 18 years old) will decrease and the level of dependence on the productive and economically active population will be reduced. On the other hand, the rapid growth in the size of the workforce (around +789 million until 2050 according to ILO, 2017) will increase the pressure on labour markets which are already close to saturation, and influence structural changes and agricultural choices. However, this evolution should not hide the fact that SSA is also an ageing continent thanks to improvements in healthcare and sanitation. Also, SSA will be the only region of the world where the rural population and rural density will be growing well beyond 2050 (ILO, 2017). Therefore, in the five Agrimonde-Terra scenarios the total and rural population growth will increase tensions between uses and users of land and water (agriculture, livestock farming, urbanization and mining) (Losch *et al.*, 2016).

There are strong on-going trends towards the hypothesis '*Political and economic fragmentation*'. First, the region suffers from political instability which has caused the deaths and displacement of millions of people and has a negative impact on land use and food security. Some conflicts involve States, while others are more localized (Williams, 2011); people fight over natural resources, over religion, over political power, or ethnic groups do not get along. Second, many governments and institutions are weak and do not exercise their regulatory functions; their administrations are inefficient; some countries spend a high proportion of their budget on the army. Corruption is widespread (Kodila-Tedika and Bolito-Losembe, 2014), leading to clientelistic networks, illegal and informal trade and land grabbing. The informal economy is an important component of the economies of most countries contributing between 25 and 65% of GDP and between 30 and 90% of total non-agricultural employment (IMF, 2017). Oil exporting countries tend to have a larger share of informal economy than low-income and the middle-income countries (IMF, 2017). Third, the economic transition is incipient (Losch, 2016). SSA's economy grew at an annual average rate of about 5% in the pre-global financial crisis

period (1995-2008) and at 3.9% between 2011 and 2016 (World Bank, 2016), but some countries manage far better than others and, within a country, some groups improve their economic situation while others become poorer. The share of agricultural products in the total exports of African goods and services has considerably decreased over the past 15 years to the advantage of extractive products, and many African countries are therefore highly dependent on international market prices and vulnerable to unfair trade practices (FAO, 2017c). Agriculture still occupies 58.4% of the economically active population (FAO, 2011a), reaching 75% or more in certain Sahel and East African countries (ILO, 2017). It is a prominent occupation not only for the rural population, but also for people in urban and peri-urban areas. However, for small farmers, especially women, insecurity in access to land remains despite the fact that, in recent years, land tenure systems have evolved in a number of countries. The role of women in agricultural activities is growing; they represented 45% of the labour force in 1980 and 50% in 2010 (FAO, 2011a). There are, however, regional as well as national differences; the averages for women's agricultural activities range from just over 40% in Southern Africa to just over 50% in Eastern Africa (FAO, 2011a). However, the performance of agriculture over the decades has been characterized by ups and downs (Losch *et al.,* 2013). Shortage of electricity infrastructure undermines efforts to achieve social and economic development; half of the population lives without access to electricity and this figure is rising (IEA, 2014). Many households rely on solid biomass (fuelwood and charcoal) for cooking, with significant negative environmental and health impacts. Also, most national agricultural research systems are small, fragmented, lack human and financial resources, and still tend to focus on a large range of issues (Beintema and Stads, 2017). On average, in 2011, the per capita spending on agricultural research in poor countries was $1.51, compared to $17.73 in rich countries (Pardey *et al.,* 2016) and population growth accentuates this gap. In SSA, while the number of agricultural researchers increased during the period 2000–2014, a very large share of senior and qualified researchers were approaching retirement (Beintema and Stads, 2017). Fourth, health problems are important obstacles to development. According to the International Finance Corporation, SSA has 11% of the world's population but carries 24% of the global disease burden. Infrastructure is insufficient to provide even basic healthcare to the population. Human diseases (*e.g.,* malaria, trypanosomiasis, diarrhoea and HIV/AIDS) significantly impact the productivity of the labour force and animal diseases (especially trypanosomosis) impede the development of livestock farming.

There are also strong on-going trends towards '*regionalization and energy transition*'. More than 200 regional organizations and commercial agreements are responsible for the development of regionalization processes in SSA. This is the *de jure* regionalization process as opposed to *de facto* regionalization (Hugon, 2016) which is the result of commercial, financial, cultural and technological networks. The first form of regionalization has been reinforced with the creation of NEPAD (New Partnership for African Development) and is particularly active in Eastern and Southern Africa. The second form of regionalization is linked to intra-SSA mobility. Trust-based cross-border mobility involves grassroots non-state actors (Nshimbi, 2015); it leads to the mobility of people, animals, and goods and

contributes to regional integration. Sub-Saharan Africans move first within Africa (nearly 75% of movements) and to neighbouring countries (Mercandalli and Losch, 2017). West Africa, East Africa and, to a lesser extent, Southern Africa are the most dynamic regions in terms of sending and receiving countries, with Ivory Coast, South Africa, Nigeria, Kenya and Ethiopia being the top five receiving countries (Mercandalli and Nshimbi, 2016). African and non-African ethnic groups play a major role in intra-regional trade. The share of official intra-African trade in total trade has fallen from around 20% in the mid-1990s to 12% in 2015, which is low compared to other continents (UNCTAD statistics). This decline is due to the fact that African trade with the rest of the world has grown much faster than intra-African trade and that informal trade is not taken into account in official statistics. Adding informal trade to official trade figures would increase the share of intra-African trade in total trade to the levels observed in Latin America and the Caribbean (UNCTAD, 2013). The Southern African Development Community (SADC), for example, estimates that informal trade accounts for between 30 and 40% of intra-SADC trade (Koroma *et al.*, 2017). SSA's renewable energy resources (solar, hydro, wind and geothermal), although spread unevenly across the continent and at a different stage of development, are sufficient to meet current and foreseeable future needs (IEA, 2014).

There are also a number of trends towards the assumption '*conventional development led by market forces*' and globalization. First, economic growth and insertion in the global economy are developing. According to the World Bank (2016), "established growth performers" (Ethiopia, Mali, Mozambique, Rwanda and Tanzania) and "improved performers" (Benin, Cameroon, Ivory Coast, Democratic Republic of Congo, Kenya, Senegal and Togo) contribute to 21% of Africa's output. A few have diversified economies with significant industrial development (*e.g.,* South Africa), in other countries the mining industry financed by foreign investments plays a major role (*e.g.,* Botswana, Nigeria, Angola, Congo, Equatorial Guinea and Gabon) (UNECA, 2011), while others rely mostly on exports of non-processed and processed agricultural products. Integration in global value chains is nevertheless limited due to lack of infrastructure, including large harbours. Lebanese, Indian and Chinese networks play an important role in this evolution (Hugon, 2016). Second, external funds are flowing to SSA. These are foreign aid and foreign investments; the latter have quadrupled since 2000 (OECD/FAO, 2016), mostly targeting the exploitation of natural resources with a rapid rate of return, and aimed at establishing markets. Malaysia, China and India were among the top five investors in Africa in 2013, together with France and the United States (UNCTAD, 2013). Third, a service-based economy (*e.g.,* banking, telecommunications and retailing) is developing in cities. Agricultural research and innovation receive significant funding from a large number of bilateral and multilateral donors, development banks and private foundations (Beintema and Stads, 2017). Several countries, including Ivory Coast, Ghana and Tanzania, have established funding systems that mobilize private-sector resources. Agricultural input firms have established research and development facilities in some countries (*e.g.,* Monsanto in Burkina Faso, Kenya, Malawi, South Africa and Zimbabwe). Fourth, international institutions have promoted land registration and titling and the transformation of existing land rights "into individualized,

tradable assets that can circulate within a market economy" (Boone, 2017). A number of governments are also revising their land tenure legislation and reforming institutions for the administration of individual rights (Toulmin, 2009). This and other measures can create a favourable climate for foreign investments, including in agriculture.

There are strong trends towards the assumption '*Dominance of non-state actors'*. First, there are many initiatives by non-state actors. Traditional institutions and leaders and family heads still play a significant role in land management in a number of localities and countries, and many African farmers still hold their land through forms of customary tenure. The weak state syndrome has permitted religious and non-governmental organizations (NGOs), philanthropic foundations, as well as non-African traders and corporations to exert a strong influence. Recently, young and creative Africans (called the "cheetah generation" by George Ayittey) and the African diaspora have started to influence politics and economy. Their actions supplement the weak national and local institutions, even if their impact can be constrained by the inefficiencies of these institutions. Second, there is an evolution towards the digitalization of relationships. Under the lead of Senegal and Kenya, SSA is going digital. For mobile telephones, the penetration level in 2015 was approaching 50%, and the growth rate in subscriptions is the highest globally (GSMA, 2016). Small entrepreneurs and large corporations are developing web activities and starting to impact activities such as financial services, education, retail and agriculture, health and government. Mobile money is also used by businesses, such as commodity shops and agricultural businesses. Connectivity is a major driver of rural livelihood transformations and local development and creates labour opportunities. Third, a number of non-state actors, *i.e.* heads of families, customary chiefs and local institutions play an important role in land allocation and management. Also a mix of individual farmers, farmer organizations, research, extension services, NGOs, private entrepreneurs and externally-funded projects are often involved in agricultural innovations (Triomphe *et al.,* 2017).

Finally, there are weak signals towards the assumption '*a sustainable and cooperative world*'. SSA's voice in global governance is starting to be better heard. SSA is far more stable and better governed now than at any other time since independence (WEF, 2015). Over the past five years, a number of peaceful elections at the national level have taken place and civil society organizations have been instrumental in agitating for political pluralism, decentralization of resources and respect for human rights and the rule of law. As far as land is concerned, there are still customary practices favouring common property management, for example local agreements (*conventions locales*) for resource management in the West African Sahel, hillside enclosures in Ethiopia and community land registration in Mozambique (Toulmin, 2009). There have been significant increases in the coverage of mobile telephone services which create opportunities for social and economic inclusion (UNECA, 2017). Young Africans are increasingly returning home to pursue a career after an education abroad (ACET, 2014), thus contributing to the transformation of economic and social models. There has been a marked increase in foreign direct investment, which is a sign of confidence, and some countries are setting up rules for investments in agriculture and other sectors. Employment in the service sector (retail,

transport, distribution etc.) and the development of information and communication technologies are facilitating linkages between people (WEF, 2015). An increasing number of African governments are providing agricultural services, at least in the area of staple food production. As far as research and innovation are concerned, farmer participatory approaches and farming system research are critical components of agricultural research and have evolved over time (Norman and Atta-Krah, 2016), and there are trends towards multi-stakeholder processes in agricultural research (Hiwasaki *et al.,* 2016).

Trends relative to climate change[67]

In brief: SSA is suffering heavily from '*rapid climate change*'. It is not a major contributor to climate change and it has the potential to contribute to the '*stabilization of global warming*'.

There are many trends in SSA towards the assumption '*runaway climate change*'. Observed temperatures within the African continent have shown a warming trend since the 1960s (IPCC, 2007). Agriculture is considered particularly vulnerable due to the extensive reliance on rainfed crop production (about 96% of all agricultural land according to Aquastat), high intra- and inter-seasonal climate variability, recurrent drought and floods that affect both crops and livestock and increase spoilage, and limited economic and institutional capacity to adapt to climate change.[68,69] Deforestation and emissions taking place on the farm and in the first steps of the supply chain contribute to agricultural greenhouse gas emissions; this is exacerbated by inadequate infrastructure and market access in many areas, leading to high levels of waste on the farm and during post-harvest handling.[70] Assessments of the impact of climate change on SSA are associated with wide confidence intervals due to the poor quantity and quality of historical agricultural data and a lack of reliable data on soil properties and management practices (Schlenker and Lobell, 2010; Lobell *et al.,* 2011; Roudier *et al.,* 2011). A median value for yield loss of around –11% (–15% for the most intense warming scenarios) with, however, a large dispersion of projections, ranging from a loss of –50% to a yield increase of +90% is projected (Roudier *et al.,* 2011; Schlenker and Lobell, 2010). Results indicate median changes in aggregate production by –22%, –17%, –17%, –18% and –8% for maize, sorghum, millet, groundnut and cassava, respectively. Given the pivotal role of temperature changes, yield reductions are likely to occur in regions which are more sensitive to temperature changes, such as the Sudan region (southern Senegal, Mali, Burkina Faso, Northern Togo and Benin), than in regions which are more sensitive to rainfall changes, such as the Sahel region (Niger, Mali, Northern Senegal and Burkina Faso) (Sultan *et al.,* 2013). Projections of local sea-level rises along sub-Saharan coastlines tend to be around 10% higher than the global average. The sea level is projected to rise between 0.4 metres and 1.15 metres in a 4°C world, with a median

67. This section has been mainly written by Thierry Brunelle (CIRAD).
68. http://www.fao.org/NR/WATER/AQUASTAT/tables/WorldData-Irrigation_fra.pdf
69. http://www.intensafrica.org/pathways/
70. https://ccafs.cgiar.org/fr/blog/big-facts-focus-sub-saharan-africa#.WQC2pk21uDY

rise of 0.65 metres by the end of the century (Serdeczny *et al.,* 2016). Furthermore, energy demand is growing with rapid population growth.

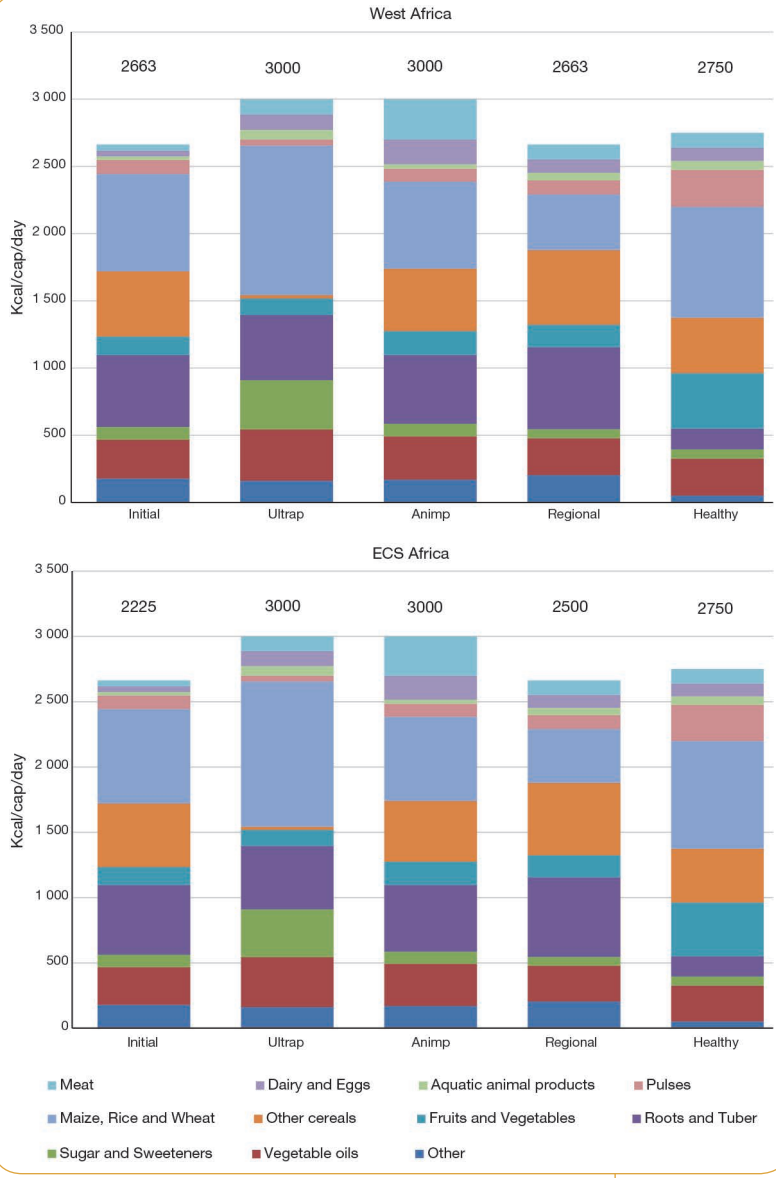
There are weak signals towards the assumption of '*stabilization of global warming*'. SSA has untapped renewable energy resources: solar across the entire continent, hydro in many countries, and wind mainly in coastal areas and geothermal in the East African Rift Valley (IEA, 2014). Also, big trees in the Congo Basin, extensive rangelands in West and Southern Africa and agroforestry offer the potential for carbon capture. Cocoa and coffee production, which have contributed to deforestation in the past is increasingly managed under agroforestry systems, and thus contribute to the reduction of greenhouse gas (GHG) emissions by sequestering carbon in trees and soils and by reduced reliance on synthetic fertilizers (Vaast *et al.,* 2016). All SSA countries have ratified the United Nations Framework Convention on Climate Change (UNFCCC), two-thirds have submitted their National Adaptation Programme of Action and 22 countries have submitted Nationally Appropriate Mitigation Actions to the UNFCCC (Nkonya *et al.*, 2016).

Trends relative to food diets

In brief: the '*regional diversity of diets and food systems*' remains strong, but a '*transition to ultra-processed foods and modern value chains*' is taking place. There are only weak signals towards '*healthy diets based on food diversity*', and no trends towards '*transition to diets based on animal products*'. Figure 15.1 presents the average diets in SSA and ECS Africa in 2010's initial situation and by 2050 under the various hypotheses for the future of food diets.

'*Regional diversity of diets and food systems*' is still high. Diets consist mainly of cereal or root staple crops and very little in the way of animal source proteins (Fanzo, 2012). The self-sufficiency ratio for the five main cereals (maize, millet, rice, sorghum and wheat) was 0.82 for SSA as a whole in the 2010s (van Ittersum *et al.,* 2016). In West and Central African cities, local starchy products (maize, cassava, sorghum and, to a lesser extent, yam and plantain) are still heavily consumed. Animal and sauce products (vegetables, legumes, oils, sugar and condiments), fruit and beverages are mainly locally sourced (Bricas *et al.,* 2016). In the humid regions of East and Central Africa, green bananas and plantain are used as the base of the main dish which is eaten with a relish made from roots and tubers, with the addition of groundnut sauce or red palm oil (Oniang'o *et al.,* 2003). Bush meat is common in the diets of rural and urban population in the Congo Basin and is estimated at around 3.2 million tonnes (and over 4.5 million tonnes are extracted) (Nasi *et al.,* 2011). The traditional diet in Southern Africa is centred on maize or rice, served with a stew; chicken and beef are widely eaten. All over SSA, there are territorial value chains with collectors, wholesalers, artisan food processing and small retailers on the roads, in streets and local markets despite the entry of regional and international players into both the modern grocery and food service sectors. The activities that take place around markets are often undertaken by women. Family links or kinship, *i.e.* relational proximity, between farmers and traders,

Figure 15.1. Average food diets in the initial 2010 situation and by 2050 under the various hypotheses for the future of food diets (kcal/capita/day).



Source: GlobAgri-AgT.

and between traders in the chain of collectors-wholesalers-retailers, is observed in all types of food chains, short or long (Moustier, 2017). The number of retailers and their scope has expanded to meet the evolving demand. Urban congestion, weak public transport systems and erratic electricity service, which hinders the spread of refrigerators among consumers, help traditional retailers to maintain a substantial share of the consumer market compared to larger modern retailers.

A '*transition towards ultra-processed food and modern value chains'* is taking place. Diets are being transformed due to rising incomes and consumers look for foods that are convenient to buy, prepare and consume. In cities, imported wheat and rice are dominant in the starchy products consumed. Large supermarkets are developing rapidly all over SSA (Staatz and Hollinger, 2016). There is not a marked '*transition to animal-based food*'. Chauvin *et al.* (2012) note that "calories supplied by meat consumption in SSA have been increasing by an average rate of more than one per cent per decade". This increase is mostly associated with the higher income levels that allowed consumers to afford income elastic commodities such as meat. However, in countries such as Cote d'Ivoire, Democratic Republic of Congo (DRC), Ethiopia and Kenya, meat consumption has decreased sharply. This decrease is mostly associated to drought condition which decreased livestock weights and increase their mortality in countries such as Ethiopia and Northern Kenya and civil war in Cote d'Ivoire and DRC which affected local meat supply." Milk products are the most commonly consumed animal product. The consumption of poultry, eggs and pork has increased while the consumption of beef is decreasing and the consumption of small ruminants is constant. Fish make up the lowest source of animal calories and are consumed in a few coastal countries, especially Ghana.

The regional diversity of diets and value chains is just about the only weak signal towards the assumption of '*healthy diets based on food diversity*'. Indeed, the consumption of animal products (with the exception of Southern Africa) and of fruit and vegetables is still below recommended levels. This situation has negative impact on birth weight, growth and cognitive development. These foods are either not accessible because of their high cost, not locally available, unequally distributed within households or are not considered household priorities when incomes are not sufficient to meet the needs of a high quality diet (Fanzo, 2012).

Trends in direct drivers of changes

We examine here the on-going trends and weak signals in SSA towards the hypotheses relative to the direct drivers of land use change, *i.e.* urban-rural relationships (Chapter 9), farm structures (Chapter 10), cropping systems (Chapter 11) and livestock systems (Chapter 12).

Trends relative to urban-rural relationships

In brief: urban-rural relationships in SSA are diverse and influenced by population density, history and geographical situation, and there are trends towards the four hypotheses of change proposed by Agrimonde-Terra.

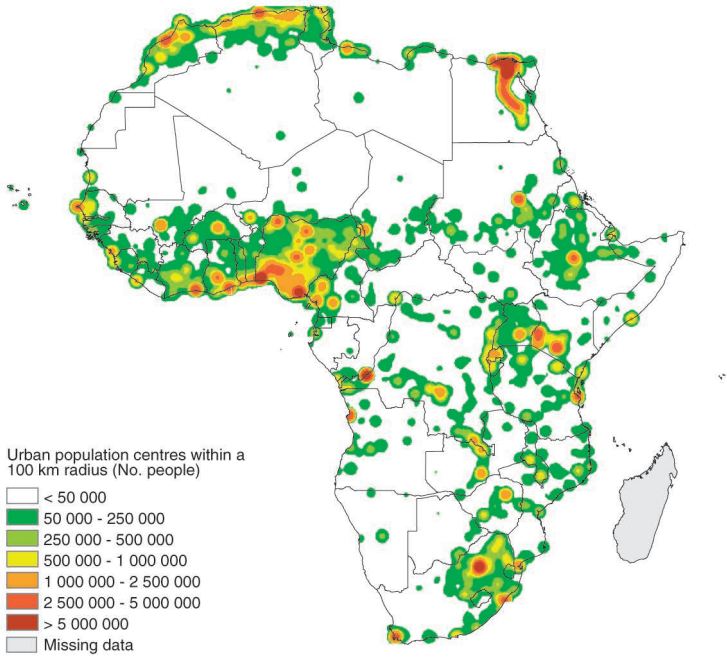
There are a few cities of over three million inhabitants in SSA but these 'megacities' are included in vast urban clusters ('*large metropolitan regions*') (Figure 15.2). In West Africa, from the coast of the Gulf of Guinea to the Sahel, urban population density is high, with the major cities being Lagos, Onitsha, Abidjan, Accra, Kano, Dakar, Bamako and Ibadan. In the Ethiopian Highlands, around Addis Ababa, a dense urban network has developed. In the Great Lakes region, there is a conurbation in Western Kenya, close to linking Nairobi to Kampala. In the Northern part of South Africa and in the extreme South of Mozambique, an urban network starts around Johannesburg and stretches towards the interior of the country regions (Chatel *et al.,* 2016). Also, "corridors of urbanization are emerging between Lake Chad and the Ethiopian Highlands", between the borders of Cameroon and Nigeria and the Great Lakes, "as well as along the railway line and roads leading to the mining regions from Pointe-Noire in DRC, crossing Zambia and Zimbabwe and reaching Mozambique. ... More isolated large cities such as Cape Town, Luanda and Khartoum result in polarization in their surrounding regions" (Chatel *et al.,* 2016).

Despite the poor quality of the roads, the road system plays a key role in '*rural-urban archipelagos*' and facilitates '*multi-activity within households*'. Temporary movement – whether daily, weekly or seasonally – characterizes the mobility pattern of households in search of employment, services, commercial goods and education as well as for social reasons (Steel and van Lindert, 2017). They take place, for example, between rural areas and middle-sized cities in West Africa. People take advantage of progress in electrification, low-cost public or individual transport, mobile phones and money transfer applications to move from one place to another and find non-farm jobs. Households receiving international remittances are able to buy land and build a house, to establish a business or to buy agricultural equipment, which helps them to become multi-active (Plaza and Ratha, 2011).

The '*integration of rural areas into urban networks*' is limited by the slow development of intermediate urbanization (Andersson Djurfeldt, 2015). Nevertheless, there is '*a new emerging rural world*' (Losch *et al.,* 2013; Pesche and Diop, 2016) and value chains link rural and urban areas. As cities consume predominantly African products, urban food markets lead the development of local food chains which have both an informal and a formal component (Schaffnit-Chattrjee, 2014; Bricas *et al.,* 2016; Staatz and Hollinger, 2016).

Finally, there are weak signals towards '*urban fragmentation and counter urbanization*'. This trend is due to difficult living conditions in the large cities, especially the high cost of living, lack of infrastructure and employment opportunities, and violence. For example, in South Africa, middle class families are starting to migrate from urban to rural areas (AfDB, OECD and UNDP, 2016).

Figure 15.2. Map of Africa - urban centres with a 100 km radius



Source: Chatel *et al.* (2016), Figure M8, p 20

Trends relative to farm structures

In brief: there is a great diversity of farm structures (Bélières *et al.*, 2015) and therefore there are on-going trends towards the six Agrimonde-Terra hypotheses relative to farm structures in 2050. Farms of two hectares or less contribute to around 30% of most food commodities and 25% of nutrients; farms of 20 hectares or less produce more than 75% of most food commodities and 80% of nutrients (Herrero *et al.*, 2017).

'*Marginalized farms for a livelihood survival*' are both an on-going and an emerging type of farm. Such farms have existed for many years because many farmers lacked access to capital; they also had limited access to markets, education, extension services, farmers' associations, banking and financial services. It is an emerging trend because of the growing number of farmers and the unstable land tenure systems. For several or more decades, farm sizes should continue to shrink as well as a movement to marginal land. Between 1961 and 2003, the average land area available per active farmer has shrunk from 1.6 to 1 hectare (Bélières *et al.*, 2015). About 60% of farms in sub-Saharan Africa cover less than

1 hectare and another 20% have between one and two hectares (Bélières *et al.,* 2015). A number of these farms are fighting for their survival and are confronted with a number of impasses (climatic, biotechnical, lack of labour, insecure land access, difficult access to resources or credit, soil degradation, competition for water etc.). Many women have insecure access to land and are therefore marginalized farmers.

Small SSA farms with about 2 hectares of farmland and rudimentary equipment, generally manual, have been able to make a significant contribution to supplying cities both in basic food products (cereals and tubers) and in food diversification products, such as vegetables, milk, fruit and oilseeds (Bélières *et al.,* 2015). Agrimonde-Terra identifies them as '*resilient farms embedded in urban processes*'. The households of these farms are able to cope with disruption as some members of the family work on the farm while others have off-farm activities. The remittances of members of the family living abroad or in big cities play an important role in daily life and investments.

'Independent farms but commercially dependent' can take different forms. In the cotton basin of West Africa, for example, farms are linked to local value chains (cotton, maize, cattle, small ruminants etc.). Suppliers of inputs, equipment, financial and advisory services, and processors, wholesalers and retailers are all active in the value chains (Ouedraogo and Vall, 2016). Also, a growing number of medium-scale farms (5 to 50 ha) are being developed by pluri-active and often urban-based Africans who seek a stable long-term return on their investment (Sitko and Jayne, 2014; Anseeuw *et al.,* 2016). They secure their access to land through long-term leaseholds or title deeds, and often hire a relative as manager to look after their operations. Their activities lead to land concentration (Jayne *et al.,* 2014). This phenomenon appears to be associated with the rise in global food prices, the development of markets for agricultural inputs and mechanization, policies favouring commercialized agriculture and democratic processes (Jayne *et al.,* 2016).

'Hit and run strategies for agro-investments' are emerging. These can take different forms (Cotula *et al.,* 2009) and are developing with the support of a number of African governments (Smalley, 2013). The most common form is the result of investments by foreign companies which integrate Africa in their global projects to control production factors or to diversify their activities. They can rent large-scale areas, produce energy, control logistics, and sell fertilizers and pesticides as well as improved seeds and breeds. As far as large-scale acquisitions are concerned, the Land Matrix 2016 reports that SSA "accounts for 422 concluded agricultural deals (42% of all deals) and 10 million hectares (37%). It also has the highest number of intended deals (147 deals; 13.2 million hectares). Land acquisitions are concentrated along major rivers and in East Africa" (Nolte *et al.,* 2016, p.vi). The five most targeted countries according to the size of concluded deals are Ethiopia, Ghana, South Sudan, DRC and Sierra Leone (Nolte *et al.,* 2016).

There are emerging trends towards '*agricultural cooperatives emphasizing quality*', even if cooperatives have left a poor legacy in many African countries, national legislation is often inadequate for establishing and developing cooperatives, and states too often intervene in their management (Develtere *et al.*, 2008). Nevertheless, there are examples

of successful initiatives in incorporating small-scale farmers into value chains in East Africa (*e.g.,* horticultural products marketed by Balimi farmers in Tanzania and potato growers in Uganda) (Louw *et al.,* 2008) and in West Africa (Gning and Larue, 2014). Another trend towards cooperatives is the development of user-managed rural and village banks (Jessop *et al.,* 2012).

Finally, there are '*farms producing goods and services to surrounding community*' as SSA farms have a history of stewardship of resources and know-how to manage the complexity of common systems. Pastoralists and smallholder farmers practicing agroforestry (Mbow *et al.,* 2014) are examples of farms contributing to the enhancement of soil fertility, carbon sequestration and provision of fuel. Some provide these goods and services through the mediation of their local community, but rarely through the mediation of local governments.

Trends relative to cropping systems

In brief: all four hypotheses for the future of cropping systems are found, even if these descriptions do not fully apply to SSA. There is significant room for improved performance due to generally weak performance in the past (Benoit-Cattin and Dorin, 2012; Fuglie and Rada, 2013).

'Conventional intensification' has been promoted by agricultural policies and extension services over the course of several decades. For the period 1961-2012, total factor productivity (TFP) increased at an annual average growth rate of only 0.5% and labour productivity improved more slowly than land productivity (Benoit-Cattin and Dorin, 2012; Benin, 2016). The highest annual average productivity growth rates have been in Southern Africa for land and in West Africa for labour. Central and East Africa has had the lowest level of land and labour productivity. Intensification and specialization in production is mostly practiced in the highland perennial farming systems, and especially the maize mixed farming system of East and Southern Africa (Garrity *et al.,* 2012; Leclerc *et al.,* 2014; Sheahan and Barrett, 2017). It is also practiced in irrigated farming systems, for example in the delta of the Senegal River and in some areas in Sudan and South Africa (Siebert and Frenken, 2014), and in peri-urban areas (Temple *et al.,* 2008) (Figure 3). It has been practiced in the cotton production zone of West Africa but changes in cropping systems are on-going (Toillier and de Lapeyre de Bellaire, 2017). It relies on the improvement of imported varieties and breeds, pesticides and mineral fertilizers. The incidence of irrigation and mechanization seems to have remained small (Sheahan and Barrett, 2017). The use of inorganic fertilizer and agrochemicals is relatively low as an aggregate but more widespread than is commonly recognized, and with considerable variation within countries and between countries (Morris *et al.,* 2007; Sheehan and Barret, 2017). The use of fossil fuel-based inputs was promoted and subsidized in SSA from the 1950s to the 1990s for many crops, but structural adjustment programmes have stopped this practice. Since the mid-2000s, a number of countries have returned to fertilizer subsidies and stable fertilizer prices to promote the production of basic foods despite controversies (for example, Zambia in Neubert *et al.,* 2011). As far as pesticides are concerned, South

Africa represents more than half of SSA's consumption (Sheahan and Barrett, 2017); national regulations are either absent or not respected and tend to lead farmers to the purchase of older pesticides or poor quality and less expensive ones (UNEP, 2013). Also fallow practices for regenerating soils are disappearing (Binswanger-Mkhize and Savastano, 2017). Dugué *et al.* (2014) observe that in West Africa farmers tend to prefer the conventional intensification/Green Revolution model over agroecology. Several reasons explain this preference: mineral fertilization remains effective and profitable in these regions where the risk of drought during the cycle is lower than in the Sahelian zone; if farmers are able to buy them, mineral fertilizers are available in large quantities, which is not the case with organic manure whose availability is often reduced; farmers are abandoning fallows and cultivating continuously, which requires the growing use of fertilizers and herbicides; active ingredients in herbicides have fallen into the public domain and their costs have decreased; and consequences on the environment and health of fertilizer and pesticide use are largely unknown (Dugué *et al.*, 2014).

'*Sustainable intensification*' is increasingly promoted by donors and international research institutions (The Montpellier Panel, 2013; Öborn *et al.*, 2017). It means a shift from on-going practices to practices which optimize outputs and maintain the farm in a healthy ecological and financial state, and contributes to increased production, income, nutrition and ecosystem services. Gautier *et al.* (2016) report that in West Africa, "the most frequently reported agricultural responses are changes in cropping systems and patterns, crop diversification or changes in crops and varieties, exchange and selection of seeds, changes in sowing dates or in the agricultural calendar, changes in the location of fields, the adoption of water saving and soil conservation techniques and finally agricultural intensification". In Burkina Faso, Dabat *et al.* (2012) note that farmers have intensified cowpea production because of market opportunities and this production has positive impacts on nitrogen fixation and soil fertility, cereal production and the association of crops and livestock. The European Union-funded PROIntensafrica project identified different pathways leading to sustainable intensification through *in situ* case studies; they demonstrate the richness and variety of options that are open to farmers.[71] Himmelstein *et al.* (2017) report that on average, in Africa, intercropping increases crop yields by 23%, but effects vary significantly depending on management practices and agro-ecological factors.

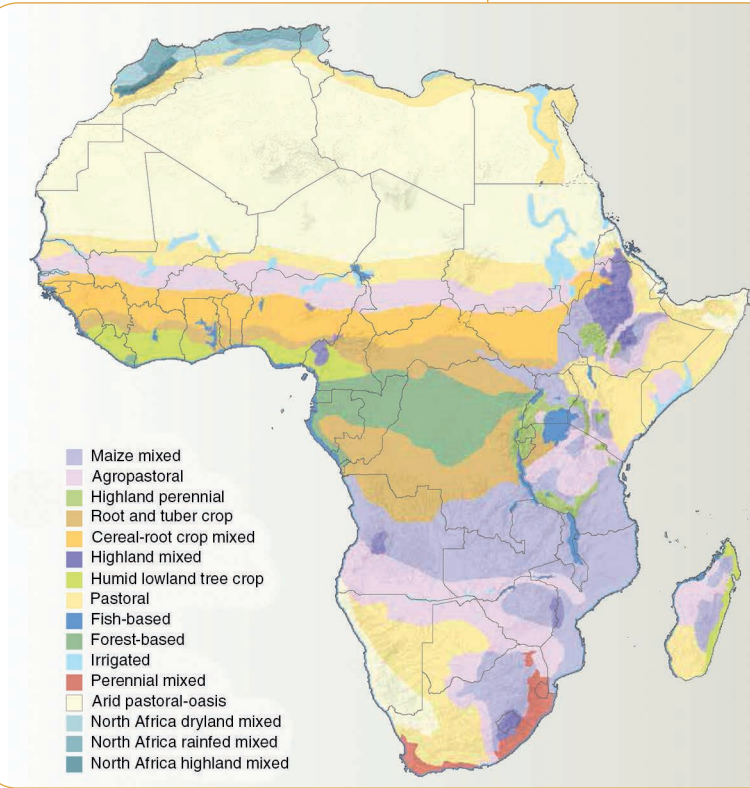
'Agroecology', i.e. the diversification of crops (including agroforestry) and/or association of crops and livestock, and techniques to restore soil fertility is still practiced in some areas of SSA, and is promoted by some research and development projects as it contributes to agricultural resilience. When livestock and crops are associated, livestock provide many services to farmers, such as meat and milk, but also the recycling of nutrients and manure, energy and maintenance of the vegetation balance. Cropping systems are highly dependent on labour, with animals providing draught power and low levels of

71. http://www.intensafrica.org/pathways/

mechanization; dependence on agri-industrial inputs is low. Agroecological practices were largely practiced in semi-arid areas of West Africa, abandoned during a humid period (1950-1970) and have been rediscovered and improved since the 1990s because of drought (Roose *et al.*, 2017).

Finally, a number of events are contributing to the *'collapse'* hypothesis with yield stagnation at low-yield levels or very low rates of yield gains. This is due to the lack of access to agricultural inputs, infrastructure, capital, markets and extension services, as has been reported for maize cropping (Grassini *et al.*, 2013; Iizumi *et al.*, 2014) in Chad, Rwanda, Angola, Zimbabwe and Lesotho (Ray *et al.* 2012).

Figure 15.3. Map of farming systems in Africa.



Source: Sebastian K. (2014), Map 1, p 15. Reproduced with permission from the International Food Policy Research Institute www.ifpri.org. The original map is available online at http://ebrary.ifpri.org/cdm/singleitem/collection/p15738coll2/id/128169/rec/1

Trends relative to livestock systems

In brief: most on-going trends relate to three of the five Agrimonde-Terra hypotheses: *'livestock on marginal land'*, *'agroecological livestock on land in synergy with agriculture and urbanization'* and *'backyard livestock'*. There are some weak signals towards *'conventional intensive livestock with local resources'* and even fewer trends towards *'conventional intensive livestock with imported resources'*.

In the drylands of Africa, which occupy about 60% of the land, livestock are the main, and often only, land use option, and the livestock sector is the cornerstone of the national economy in many West and East sub-Saharan African countries which contain significant amounts of drylands. Direct outputs of livestock, such as meat and milk, contribute between 5% and 10% of total GDP and and accounts for 15–40 percent of the added value in agriculture. Indirect benefits are organic fertilizer and traction services. The livestock sector is also an important source of foreign exchange; millions of sheep are shipped every year from the Horn of Africa to countries in the Persian Gulf, and about one million head of cattle are trekked or trucked from the Sahel region to West African coastal countries. An estimated 25 to 41 million people have livestock which are their sole source of livelihood, and livestock provides a significant share of income for about 110-120 people, roughly 70% of the population of the rural drylands of West and East Africa (de Haan, 2016). Livestock ownership is highly unequal: 1% of livestock keepers own between 9 and 26% of all animals, and 90% of livestock keepers are below the minimum level needed to earn an income above the poverty line. On average, between 1980 and 2010, the herd/flock size per household and per pastoralist has gone up: the annual growth of livestock has been between 3.1 and 4.4%, whereas the human population has increased by 1 to 2.5% per year (de Haan, 2016). The increase in small ruminants has been particularly fast. Traditionally, pastoralists raise livestock on marginal land as their most important source of income and agro-pastoralists combine livestock with crop farming. However, over the past two decades, arable farmers have increasingly invested in livestock whereas pastoralists have been forced to take up cropping because their herd sizes fall below the minimum size need to sustain their households (de Haan *et al.*, 2016). Competition over access to dry season grazing and water between farmers and herders is therefore growing.

'Livestock on marginal land' is practiced in resource-scarce and climatically marginal regions which are sparsely populated and often have highly variable conditions. The agronomic potential of these areas is very low and they could not be cultivated. It is based on the grazing of natural vegetation, whose nutritional and spatio-temporal distribution depends on the variability and intensity of annual precipitation. It is practised by around 25 to 50 million herders (according to sources) over approximately 43% of the African territory (the Sahel zone, the Horn of Africa and parts of Southern Africa) and contributes significantly to income. Pastoralists and their herds of camels, cattle, sheep and goats use communal land resources and move from one area to another according to feed and water availability. Pastoralists have contributed to

the stabilization of the societies living in the zones; they have spread important know-how within society and along transhumance routes and contributed to linkages between countries. Animal mobility contributes to the exploitation of natural areas unsuited to other activities, stimulation of pasture growth, provides manure and preserves biodiversity; animal products end up in urban areas for domestic markets and exports. The sparse distribution of livestock makes epidemic disease outbreaks quite infrequent and the main threats for animals are parasites, nutritional deficiencies, and the lack of feed and water. Livestock production on marginal land faces many risks. Conflict and insecurity are prevalent. Climatic events, especially drought, can be dramatic. Livestock diseases can emerge suddenly (*e.g.,* Rift Valley Fever) with related sanitary bans (de Haan *et al*., 2016). Governments can have an ambivalent attitude towards mobility, and pastoralists face shortcomings in administrative and regulatory procedures which lead to illegal movements of livestock and violence, for example between Chad and the Central African Republic. Some countries are setting up pastoral and land codes to address the sharing of resources between pastoralists and farmers. Mobility to farmed areas is leading to conflicts with farmers and modifying both livestock and cropping systems. Finally, pastoralists face daily trade-offs between selling their milk, meat and eggs to increase income and consuming the same foods to improve nutrition.

Mixed crop-livestock systems, *i.e. 'agro-ecological livestock on land in synergy with agriculture or urbanization'* are found throughout Western Africa, Eastern Africa and parts of Southern Africa. Rural people rely on livestock which is totally or seasonally mobile in different proportions, and on combinations of crops (mainly millet, cowpea, sorghum, cotton and groundnut). "Populations have adapted their farming systems and way of life to the spatial and temporal (seasonal and inter-annual) rainfall variability and its resulting uncertainties on production of crops, trees, and grazing resources" (Garrity *et al.,* 2012, p. 24). Drought is a regular phenomenon. The primary concern in the mixed crop-livestock systems is to ensure the survival of animals, limit losses, maintain productive capacity and minimize the risk of failure to produce a means of subsistence. Tsetse flies and disease limit the presence of livestock in many areas of Africa.

Most families, in rural and even urban areas, have poultry and small ruminants in their backyard fed on waste and marginal land (*'backyard livestock'*).

There is the development of *'conventional intensive livestock production with local resources'*, especially for pigs and poultry. Producers are a mix of family businesses and commercial operations, ranging from the small- to large-scale with varying degrees of modern technology. The main challenges for this development are the lack of large quantities of maize, soya, day-old chicks and broiler producers, the high price of feed materials, lack of training and credit and the slow development of the consumer market. There are still many risks associated with intensive production of ruminants and monogastric animals such as zoonoses and their impact on human health, the concentration of animal waste, breed specialization and lack of feed.

The Agrimonde-Terra scenarios in sub-Saharan Africa

In this section, we present the main on-going trends towards the five Agrimonde-Terra scenarios (Chapter 13) in SSA and examine what the land use and food security situation could be in SSA in 2050 with each scenario.

On-going trends in SSA towards the five scenarios

There are on-going trends concerning both the external and direct drivers of land use change towards all five Agrimonde-Terra scenarios (Table 15.1). The '*Land as commons for rural communities in a fragmented world*' scenario has been dominant in the past and on-going trends towards this pathway could endure if the political and economic context remains fragmented. External drivers are providing strong impetus towards the '*Land use driven by metropolization*' scenario and the '*Land use for multi-active and mobile households*' scenario. Direct causes of change, especially the integration of rural areas into urban networks through value chains are driving towards the scenario "*Land use for regional food systems*'. And there are weak signals towards the '*Land use for food quality and healthy nutrition*' scenario. This situation could be an opportunity to improve land use and food security, or a threat if no choice is made. If key African stakeholders accept the complexity of the land use and food security system, and understand the linkages between drivers, there are opportunities for improvement. Transformational change will require systemic and systematic thinking and practice, as well as embarking "in a process of innovative design" instead of "changing procedures in the same pathway" (Hubert and Ison, 2017). It will require searching for both economic and humanitarian goals without opposing them. Rural and urban linkages, especially the growing integration of rural areas into urban networks through value chains, the dynamism of agriculture and smallholders' innovativeness, the combination of local and external knowledge, mobility and multi-activity, the growing role of civil society organizations, the growing implication in SSA of the African diaspora and renewable sources of energy are all some of the positive trends towards the establishment of a positive future for land use and food security in SSA.

Short narratives of the five scenarios in SSA

The Communities scenario in SSA

Global economic and energy crises affect SSA less than the rest of the world because of the generally low consumption level, but, nevertheless, crises in developed countries are shocks for African countries and increase their fragility. They lead to poor economic growth, major decreases in foreign aid, lack of investments in infrastructure, education, and research in SSA, and difficult access to knowledge and resources. Relational logic dominates African society. Political authorities are unable to create a favourable framework for economic growth. Land tenure systems are not revised and access to land remains

insecure for smallholders. Some local communities of farmers, which have gone through social and economic upheavals and environmental degradation for decades, have managed their activities 'under the radar', adopting agroforestry practices, diversifying their production, associating crops and livestock, adopting practices to manage soil fertility, developing backyard livestock and trading among themselves. Their income and access to food increase and they manage to help their relatives who have stayed in urban areas. There are other communities which had specialized their production, for example in maize or perennial crops. They suffer from difficult access to inputs, a decrease in production, high costs of imports and declining income, and therefore face difficult access to food, undernutrition and nutritional deficiencies. In mineral-rich countries, minerals are exported but the benefits are kept by a few groups; some manage to get access to food while others are unable to do so and migrate first within SSA and if necessary outside SSA. In cities, some people manage to get jobs, but not others. In the areas where communities have secure access to land, manage efficiently scarce resources, avoid high levels of population growth and adopt agroecological approaches, the agronomic potential stabilizes; there is a diversification of production and the impact of extreme weather events on crops and yield variability is reduced. In the areas where communities are unable to organize themselves, where there is too much corruption, ethnical fights, terrorism and instability, the agronomic potential reduces, and cropping and livestock systems collapse; the effects of climate change cannot be mitigated. The calorie availability per capita stays as in 2010 in West Africa (2,663 kcal/cap/day) and increases slightly in ECS Africa (rising from 2,225 kcal/cap/day to 2,500 kcal/cap/day).

The Metropolization scenario in SSA

The alliances between a number of African governments and institutions, United Nations institutions and multinational companies and investment funds contribute to lowering trade barriers in order to foster international investments in SSA, to facilitate secure access to land for foreign investors, to facilitate the export of mineral resources and the import of goods and ultra-processed foods, and a green revolution. The objective is economic development and the insertion of SSA into global value chains. Agri-industrial and commodity trading companies develop large farms, using improved varieties and breeds, inputs and large-scale mechanization, promising to feed the growing African population living in large cities. In the capital cities, coastal cities of West Africa and a small number of urban agglomerations, substantial investments in infrastructure (notably industry, energy, education and health) and services (in terms of skills improvements for effective business support and efficient banking systems) are made. The secondary cities and the rural areas do not benefit from these investments; they are forgotten. Over several decades, millions of African smallholders are displaced because of climate change or land grabbing. Some move to the slums of the large urban areas, others to marginal rural areas; youth tend to move to the urban clusters. During the first decade, there are informal and formal job opportunities for unskilled workers, but they decrease over time because of the evolution of technological development. In large urban areas,

Table 15.1. Main on-going trends in SSA towards the five Agrimonde-Terra scenarios.

	Communities	Metropolization	Households	Regionalization	Healthy
External drivers of change	– Strong political and economic fragmentation: instability and poor governance in many countries; corruption; violent conflicts over resources (*e.g.* Lake Chad). Large informal economy. Human health problems (AIDS, malaria etc.). – Warming temperatures and extreme climatic events. – Diets based on cereals (West and Southern Africa), roots, tubers and plantains (Central). Local production of meat, fruit and vegetables. Local processing and markets. Corridors for trade (*e.g.* Ouagadougou-Accra).	– Some countries integrated in global agricultural value chains (*e.g.* South Africa, Côte d'Ivoire, Ethiopia and Kenya). Foreign investments multiplied by four since 2000. Development agencies promote liberalization and privatization. State sovereignty at stake. – Warming temperatures and extreme climatic events. – Growing imports of wheat and rice. Transition to ultra-processed food. Development of supermarkets. Growing over and mal nutrition.	– Growing number of dynamic, mobile and multi-active Africans. Development of decentralization and digitalization. Weak state syndrome. Informal economy. Alliances between varieties of stakeholders. – Carbon sequestration processes. – Diets based on cereals (West and Southern Africa), roots, tubers and plantains (Central). Local production of meat, fruit and vegetables. Local processing and markets. Corridors for food trade (*e.g.* Ouagadougou-Accra).	– Many regional organizations with overlapping. Development of civil society organizations. Intra SSA mobility for humans, animals and goods. Informal trade. Abundant but unevenly spread energy resources. – Carbon sequestration processes. – Diets based on cereals (West and Southern Africa), roots, tubers and plantains (Central). Local production of meat, fruit and vegetables. Local processing and markets. Corridors for food trade (*e.g.* Ouagadougou-Accra).	– Civil society promotes pluralism, respect for human rights and decentralization. Peaceful elections in a few countries. Urban Africans starting to invest in SSA. Better-heard SSA voices in global governance. – Carbon sequestration processes and development of renewable energy. – Diets based on diversity of products (increased consumption of fruits and vegetables, pulses, meat, dairy and eggs) for improved nutrient content. For promotion of healthy diets: public health policies and education of women.
Direct drivers of change	– Slowdown in urban concentration; medium-sized cities and continuous increase of rural population. – Mostly insecure land and property rights; marginalized farmers. – Pastoralism in Sahel, Horn of Africa and parts of Southern Africa; backyard livestock. Multiple functions of livestock. – Agroforestry, crop-livestock associations. Picking and hunting provide revenues and employment (*e.g.* Central Africa). Some communities overexploit or intensify without resource management strategies. Other communities provide large share of nutrients, innovate and take care of resources.	– West and Southern Africa; megacities in vast urban clusters. – Investments in agriculture by urbanites; land-grabbing. Decreasing size of farms. Marginalization of rural population (*e.g.* in Congo Basin). – Deforestation, land degradation. Conventional intensification (maize in Eastern and Southern Africa, cotton in West Africa) promoted by extension services. Some areas connected to global value chains (exports of natural resources and agricultural products). Collapse of cropping systems in marginalized areas, not connected to markets.	– West Africa: multi-active and mobile households in rural-urban archipelagos. – Independent farms with commercial dependency (*e.g.* Cotton Basin in West Africa, Senegal River Delta). – Pastoralism and agro-pastoralism, and multiple functions of livestock. – Agroforestry, crop-livestock associations.	– West Africa: rural areas integrated into urban networks through value chains. – Independent farms with commercial dependency (*e.g.* Cotton Basin in West Africa, Senegal River Delta). – Farmers' knowledge of natural resource management. – Pastoralism in Sahel, Horn of Africa and parts of Southern Africa. – Sustainable intensification and agroecology promoted through participatory approaches.	– Megacities in vast urban clusters in West and Southern Africa. Some rural areas integrated into urban networks through value chains. – Development of cooperatives (*e.g.* horticulture of Balimi farmers in Tanzania, potato growers in Uganda). – Pastoralism in Sahel, Horn of Africa and parts of Southern Africa. – Sustainable intensification promoted among smallholders. Assisted natural regeneration to restore degraded forests.

people mostly consume imported ultra-processed food, with high fat and sugar content; and malnutrition, overweight and non-communicable diseases become very frequent. Before 2050, it appears that, on most large farms, yields have not increased as promised; climate change at the global level has very negative impacts on the agronomic potential of soils, yields and the nutrients of plants; the use of chemical inputs has also had negative impacts on health and the environment. Also, increasing water demand in cities and for irrigation creates severe tensions; in large cities, there are areas where well-educated and rich people live, surrounded by slums. This leads to conflicts in urban areas, hunger riots, deaths caused by starvation and malnutrition, and massive migrations within Africa and to the rest of the world. In rural areas, conflicts over resources are extremely frequent.

The Regionalization scenario in SSA

The evolution of the global economic environment leads Africa to realize that it has no choice but to decisively consolidate and build its regional trading market, its monetary integration and political concertation. African governments realize that integration means thinking regionally as well as locally. They decide 'to mark their territory' and define together an attractive vision for Africans: Africa will take advantage of its natural resources and its fast-growing population. It will seek as little dependency from the rest of the world as possible. Actions are taken to secure access to land for Africans, to monitor and control deforestation, and to facilitate access to infrastructure and markets for smallholders. Boosting intra-African trade, substituting imported products with local ones becomes a priority; tariff and non-tariff barriers are modified. Policies are adopted to promote the consumption of local and traditional food and to develop small agri-industries for food processing. In West Africa, the daily calorie intake is similar to the initial situation but intake of meat (mostly small ruminants), dairy products and eggs as well as fruit and vegetables and local cereals increase; consumption of rice, maize and wheat decreases. The consumption of fruit and vegetables and pulses is, however, still below the levels of a healthy diet and the consumption of roots and tubers above. In ECS Africa, the daily calorie intake increases with substantial growth in the consumption of meat, dairy and eggs, as well as roots, tubers, pulses, fruit and vegetables. Rural areas are integrated into urban networks through value chains. Efforts are made to employ youth in agricultural production, in food processing and agri-industries and in food services. A number of farms produce goods and services for the surrounding community and therefore ecosystem services are provided. Research priorities shift to topics such as the improvement of local species, optimizing use of inputs, adopting agroforestry practices, crop-livestock associations and the control of tsetse flies. Investments are made in hydropower to develop local energy.

The Households scenario in SSA

The 'cheetah generation', *i.e.* mobile, intellectually agile and multi-active African graduates and professionals, see the opportunities that exist in SSA. They see solutions and not problems. They do not weep about poor governance and corruption. They see that it is possible to develop traditional and informal activities such as food vendors, cloth weavers

and tailors, repairmen, cattle herdsmen, farmers, blacksmiths and goldsmiths, as well as more modern activities. They see that information and communication technologies (ICT) can be used to improve education, health, agriculture and administration, rapidly and for a large number of people, taking into account the difficult access to electricity for a large proportion of the population. They develop their activities but also get involved in non-profit organizations, civil society organizations and connect with the African diaspora and a wide variety of non-state actors. They spend time analyzing and gathering information to determine breaks in the food supply chain process that create food shortages despite availability. Then they pragmatically and strategically focus on the bottlenecks in conjunction with relevant groups, making sure they work with honest and transparent partners. For example, they recognize early on that insecure access to land is a major constraint for farmers, especially women, and their influence leads to new land tenure systems and secure access to land. They also facilitate the sharing and maintenance of silos, of grain milling machines, of oil presses, of food depots etc.; they organize training of farmers by farmers. They are entrepreneurs and their activities lead to the development of a spirit of entrepreneurship in Africa. A great number of households benefit from this system and improve their farming and non-farming incomes; mobility facilitates access to food.

The Healthy scenario

At the international level, the limits of resources are well understood and production practices, including agricultural production, have changed. So have diets in order to decrease health costs. SSA governments, conscious of the availability of natural resources and the demands of the fast-growing population, enact policies to promote healthy diets and to contribute to the fight against climate change. They also adopt major reforms to fight corruption, ensure efficient and honest administrations, develop education and health services, and improve water and electricity distribution. Land reforms are adopted in order to secure access to land and encourage farmers to produce quality products. There is full transition to sustainable intensification and agroecology, with diversified production and agroforestry practices. Agricultural practices favouring carbon storage in the soils, especially in pastures, are adopted; land degradation neutrality objectives are reached. Cooperatives and farms are embedded in urban processes. Revenues increase thanks to the diversification of production and activities, quality products and payments for ecosystem services. Diversification of production also improves food utilization and stability for all consumers. The transition to healthy diets contributes to ending undernutrition and nutritional deficiencies. It is facilitated by the education of women, public health policies, trade regulations, support for the production of healthy African products and the development of value chains. Diets are more diverse and balanced; all over SSA, the intake of fruit and vegetables, local cereals, pulses, poultry meat, dairy and eggs increase compared to 2010. The development of the local production of these healthy products increases and creates employment for the local population. In ECS Africa, the daily calorie availability per capita increases as well as the consumption of other cereals.

Lessons on land use and food security in 2050 in SSA from the five scenarios

Lessons on land use and food security in 2050 in SSA from the scenarios can be drawn from the qualitative information issued from the hypotheses and experts' advice. Also, the impacts of each scenario in West Africa, and Eastern Central and Southern Africa (ECS) on the agricultural land areas, production and trade have been simulated with GlobAgri-AgT (Chapter 14). The impacts of the five scenarios on the dimensions of land use and food security and on trade dependency are summarized in Table 15.2.

Quantitative results in SSA must be interpreted with great care. First, the quality of the data available in SSA is poor and that heavily influences the results of the modelling work.[72] Despite improvements in censuses and household surveys, national statistical systems in SSA are weak. Glassman and Ezeh (2014) report that "measurement of fundamentals such as births and deaths, growth and poverty, taxes and trade, land and the environment, and sickness, schooling, and safety is shaky at best" due to the limited independence and unstable budgets of national statistics offices, misaligned incentives encouraging the production of inaccurate data, donor priorities which dominate national priorities, and the limited access and usability of data; Ickowicz *et al.* (2014) plead for an information system on pastoralism in the Sahel.

Second, in the GlobAgri-AgT model, the rules adopted to translate hypotheses about future diets in the Agrimonde-Terra scenarios into quantitative assumptions (Chapter 14) lead to an increase of daily calorie availability per capita (especially in ECS Africa which has a low initial level of 2,225 kilocalories/person/day), and more importantly, a rise in the share of animal products in food diets (Figure 15.1). These hypotheses about future food diets, combined with hypotheses about population growth, lead to major increases in animal products consumption, whatever the scenario. Finally, the diversity of SSA countries in terms of population density, natural resources and income, also calls for a very careful interpretation of quantitative results relating to land use. According to the UN's world population prospects (2015 revision), the average population density in SSA was 38.6 people per km² in 2010 and 44.3 in 2015; Western and Eastern Africa have an average population density of about 59 people per km², and the population density in Central and Southern Africa is around 23 people per km². The diversity is even greatest at national level. In 2015, Rwanda had the highest population density (415 people per km²) and Mauritania the lowest (3.5 people per km²), and in between there were, of course, many varying situations, *e.g.*, 83 in Kenya, 64.2 in Ivory Coast, 48.3 in Cameroon, 12.4 in Mali and 7.1 in the Central African Republic. Differences in population density result in

72. The FAO (2009) report entitled 'How to feed the world in 2050. High Level Expert Forum. The special challenge of Sub-Saharan Africa' considered that only two countries in Africa have high standards in data collection.

major differences in cultivable area per person and in total per capita water availability which influence land use and household food security. The variety of situations calls for carrying out foresight exercises at national geographical scales.

As far as food security is concerned, there is quantitative information relating to average kilocalories per person and per day and the composition of diets. Information about food access (physical and financial), food utilization and stability, which is important for households, is found in the scenario narratives.

This being said, according to our hypotheses, ensuring SSA's food availability in 2050 will involve expanding SSA's agricultural land area to the detriment of forest in all scenarios. In some scenarios, this agricultural land expansion is likely to be unsustainable, especially in Western Africa.

In 2010, West Africa's observed agricultural area (arable land and permanent crops plus pastures and meadows) covers 243 million hectares. Forests cover 75 million hectares. Cultivated (*i.e.*, arable land and permanent crops) area reaches 98 million hectares which is lower than the maximum cultivable area (*i.e.*, GAEZ 1 to 4, Chapter 4) of 228 million hectares. In this region, in 2050, according to our hypotheses, arable and permanent crops areas increase considerably: from 98 million hectares in the initial situation to 169 million hectares with the *Healthy* scenario under technology C variant, and to 231 million hectares with the *Metropolization* and the *Communities* scenarios (Table 15.2 – West Africa). Arable land and permanent crops stay just below the maximum cultivable area of 228 million hectares with the *Healthy* scenario and with the *Regionalization* scenario. With the *Metropolization* scenario and the *Communities* scenario, arable land and permanent crops reaches the maximum cultivable area. The growth of cultivated area can be explained by rapid population growth (+192% by 2050) and changes in diets combined with weak performance of agricultural production systems today and a relatively low potential improvement. Pastures and meadows cover 145 million hectares in the initial situation, and in 2050, according to our hypotheses, pastures reach 151 million hectares with the *Metropolization* scenario Ultrap variant and around 270 million hectares with the *Regionalization* scenario because import dependence is reduced in this scenario so that greater quantities of agricultural products (including ruminant products) must be produced domestically.

In 2010 ECS Africa's observed agricultural area covers 784 million hectares. Forest areas cover 597 million hectares. The cultivated area reaches 128 million hectares which is significantly lower than the maximum cultivable area of 928 million hectares (GAEZ 1 to 4). Thus, in most ECS countries (with the exception of countries such as Rwanda, Burundi, Uganda and Malawi, which are densely populated and already cultivate more than their maximum cultivable area), there is potential for growth in agricultural areas on land which is suitable for crops.

Hypotheses about population growth from 2010 to 2050 are +155%. According to our hypotheses, in 2050, the expansion of the agricultural area will be small (about +16%) with the *Communities* scenario and the agroecology variant and the *Metropolization* scenario with the Ultrap variant (Table 15.2 – ECS Africa). With all the other scenarios, the

Table 15.2. The situation of land use and food security in SSA in 2050 according to the five Agrimonde-Terra scenarios.

	Communities **(AE-Collapse)**	*Metropolization* **(Ultrap-Animp)**	*Regionalization* **(A-B)**	*Households*	*Healthy* **(C-D)**
Access to land	Secure for some communities, insecure for others	Insecure access to land. High land prices.	Secure access to land.	Depends on regions: secure in some, insecure in others.	Secure access to land.
Distribution of land	Diversification	Specialization	Diversification	Products with higher added value	Diversification
West Africa (million ha)					
Range of agricultural areas (initial: 243)	382 (+57%)-461 (+90%)	383 (+58%)-416 (+71%)	503 (+101%)-524 (+116%)	Same as Regionalization	392 (+61%)-423 (+74%)
Arable & permanent crops (initial: 98)	231-231	231-231	191-213		169-193
Pastures and meadows (initial: 145)	151-230	151-185	267-276		223-230
ECS Africa (million ha)					
Range of agricultural areas (initial: 784)	926 (+18%)-1,430 (+82%)	897 (+14%)-1,331 (+69%)	1,097 (+27%)-1,357 (+73%)		1,205 (+53%)-1,256 (+60%)
Arable & permanent crops (initial: 127)	162-322	129-181	124-132		111-128
Pastures and meadows (initial: 656)	764-1,108	768-1,150	979-1,225		1,094-1,128
Services provided by the land (employment and ecosystem services)	Good in some communities, and few in others.	Very few. No attention to services provided by land.	Good: employment in agriculture and food systems. Attention to land management.	In some areas, collective land management improves services and employment. In other areas, few services.	Employment and ecosystem services.
Food availability av. Kcal/p/day					
West Africa	2,663	3,000	2,663	2,663	2,750
ECS Africa	2,500	3,000	2,500	2,500	2,750
Food access (physical and economic)	Uneven access. Depends on the communities.	Inequitable. Access facilitated by economic development. Easy in metropoles, but difficult in marginalized areas.	Uneven access. Depends on resources of the territory.	Access easy for multi-active and mobile households. Difficult for others.	Access facilitated by economic cooperation and food policies. Diversification of production.
Food utilization	Healthy diets for communities practicing agroecology; poor diets in urban areas.	Ultra-processed food. Poor nutritious quality.	Consumption of local food, healthy diets.	Mostly healthy diets, but some households have poor diets.	Healthy diets for most people.
Food stability	Low incomes in urban areas reduces stability.	Climate change leads to instability but international market can stabilize	Facilitated by intra-regional trade.	Risks when there are conflicts and shifts in alliances.	Stability if consumption of seasonal production is possible.
Trade dependency*					
West Africa	9%-23%	21%	5%	5%	11%
ECS Africa	12%	16%-10%	1%	1%	12%

* (imports-exports)/domestic use; all variables measured in calories.

expansion of the agricultural area will be between +53% (*Healthy* scenario with variant C) and +82% (*Communities* scenario with collapse variant). In ECS Africa, the agricultural net import dependency was 12% in 2010. In 2050, it reaches 16% with the *Metropolization* scenario and the ultra-processed foods variant, and stays between around 12% with all other scenarios (Table 15.2 – Trade dependency).

With the *Healthy* scenario, in West Africa, in 2050, according to our hypotheses, agricultural areas expand by +67%, which is above the expansion of the agricultural areas with *Metropolization* scenario with Ultrap variant (+58%) and the *Communities* scenario with agroecology variant (+57%). It is below the expansion of agricultural areas with the *Regionalization* scenario (Table 15.2). With the *Healthy* scenario, in ECS Africa, the expansion of the agricultural areas is much higher (around +56%) than with the *Metropolization* scenario with Ultrap variant (+14%) and the *Communities* scenario with agroecology variant (+18%). However, the *Healthy* scenario insures secure access to land, integration of rural areas into urban networks through value chains, and thereby leads to employment. Also, practices such as agroforestry contribute to improved soil quality and storage of organic carbon in the soils, thus higher yield potentials. Above all, *Healthy* is the scenario which contributes most to reducing malnutrition and undernutrition and to preventing the development of obesity for all the population because of diets based on food diversity.

The *Metropolization* scenario with Ultrap variant does not lead to a major expansion of agricultural areas in ECS Africa and West Africa. However, in this scenario, extreme climatic events will contribute to land degradation and food crises. Land-grabbing will probably develop. Some groups will benefit from technological developments and a "green revolution", but many farmers will not have access to land, water and inputs and will strive for survival. No attention will be paid to agricultural employment and ecosystem services. *Metropolization* scenario contributes most to inequality in access to food between urban and rural areas, and between the richest and the poorest. It also contributes to increased nutritional deficiencies, and the expansion of overweight and diet-related non-communicable diseases. Its impact on food trade dependency is significant, which means financial resources are necessary to import food. This scenario is also likely to result in increased price instability on world agricultural markets, which will be very detrimental in access to food for the poorest Africans.

The *Communities* scenario in SSA will lead to the deterioration of agricultural production performance, which is already low compared to the rest of the world. The on-going conflicts over land and water between communities, between farmers and herders, will become very important and may contribute to even more political and economic fragmentation. The number of households affected by food insecurity will therefore increase.

In SSA, the main limit of the *Regionalization* scenario is access to food, especially in West Africa. This scenario involves a limit in trade and therefore an increased capacity in local production. As West Africa is already close to its maximum cultivable area, the expansion of agricultural areas is at the expense of forests and cultivation on areas with a low agronomic potential.

Conclusion

As far as land use and food security are concerned, six important and related challenges for SSA for the next 30 years are (a) to slow down the land degradation process and improve the agronomic potential of soils; (b) to secure access to land and water for local populations, especially for women, and to reduce competition over access to land and water between farmers and herders; (c) to improve crop yields and livestock efficiencies; (d) to absorb the booming labour force of young women and men in the context of an incipient economic transition and ensure their activities provide them with an income; (e) to improve local access to food for the population, whatever its origin, and (f) to feed the fast-growing population in the healthiest possible manner to reduce nutritional deficiencies, prevent stunting and avoid the development of obesity.

The five scenarios provide different answers to these challenges, and each one raises specific questions. In the *Communities* scenario, some farmers will organize themselves, develop agroecological farms and manage land so as to provide foodstuffs, energy and environmental services. Other farmers will fail to organize themselves and become more marginalized. There will, therefore, be inequity at continental and national levels and a struggle for resources. Access to food for all will mean increasing agricultural import dependency with a high risk of food price shocks. If the *Metropolization* scenario develops in SSA as in the rest of the world, there is a major risk of spatial divide and dual agriculture, degradation of the agronomic potential of soils due to climate change, a high number of landless farmers who become jobless, increased competition in agricultural markets between locally and imported products, as well as increased malnutrition, overweight and non-communicable diseases. Given the trends in the population and the current state of industries and services, this pathway seems to have far more disadvantages than benefits for SSA. With the *Regionalization* scenario, Africans will become the primary beneficiaries of their production. However, given the demand, the reduction of imports, especially of animal product imports, is likely to lead to considerable deforestation. Regionalization in the sense of a limitation in imports and exports does not make sense for Africa. All the other assumptions of the *Regionalization* scenario are potentially beneficial for SSA. With the *Households* scenario, an important challenge will be the regulation of the influence of foreign agri-business and ICT companies on African smallholders as States will not exercise their regulatory powers. Finally, the *Healthy* scenario requires major and difficult political changes as well as changes in diets in SSA; it leads to an expansion of agricultural areas, but also to carbon sequestration in soils; it can contribute to employment in the agri-food sector; therefore, it will be globally beneficial for land use and food security but not without challenges especially in West Africa where, in 2050, arable land and permanent crops will be close to the maximum cultivable area.

For SSA, examining the whole food system instead of looking only at agriculture could contribute to an improved relationship between rural and urban areas, and the creation of

jobs in agriculture and agricultural product processing; local access to food and nutrition could thus be improved. This development of the food system could have both negative and positive effects on other sectors. The negative effects could be a redirection of investment from other sectors and an increase in labour and capital costs, while positive effects could happen through increased demand.

Given the multiple pathways which are on-going and contradict each other and the importance of the challenges, given the fact that SSA is a puzzle (Hugon, 2016), each country in SSA should develop a vision of future land use and identify the best levers to change its on-going trajectory. This can only be done through discussions at a national level with a range of public and private stakeholders. The analysis provided above can serve as a basis for discussion, but each country (or group of countries) should build its own scenarios in relation to its specific context and past trends and breaks.